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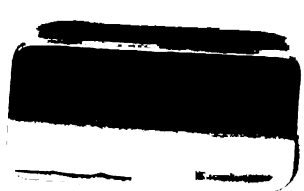

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SOME INSECTS INJURIOUS TO THE APPLE

by

JULIUS STANLEY BIRGE

A THESIS SUBMITTED FOR THE DEGREE OF

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UNIVERSITY OF WISCONSIN

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OUTLINE.

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The Codling Moth, Carpocapsa pomonella L.

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SOME INSECTS INJURIOUS TO THE APPLE.

LEPIDOPTERA.

The Codling Moth, Carpocapsa pomonella L.

Introduction:

Although the writer has made some observations on the codling moth, this paper does not assume to present original work, but is a review of the available literature on the subject. On many points connected with the life history and control of this insect, the results of investigators substantially agree; on many others there are wide discrepancies. It may be worth while, therefore, to collect the final results of the many experiments in this field, weigh them according to their relative value, and from them endeavor to arrive at some general conclusions. When an investigator publishes his records he does not simply present his conclusions, but includes the data. So in this thesis an effort has been made to submit in as convenient form as possible the results on which the conclusions are based.

Importance:

The codling moth is the most important insect pest of fruits, both in degree and extent of injury. (38). C. B. Simpson estimates that one-forth to one-half of the apple crop in the United States is injured every year, (32), and C. L. Marlatt estimates a loss of from twenty to forty per cent. of the fruit which would otherwise be sound and merchantable, or at

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least $11,400,000.00, in addition to $8,000,000.00 expended for control. (38).

Fruits Attacked:

The apple is the crop by far the most injured. Pear orchards are sometimes seriously infested, especially in the neighborhood of a badly neglected orchard which is not bearing enough apples to satisfy the crop of larvae. Simpson writes of reports which show that peaches, plums, cherries, quinces and apricots are attacked, but under ordinary conditions their injury amounts to almost nothing. (32). S. E. Foster presents interesting evidence which shows conclusively that the English walnut is in some sections quite generally, though lightly, infested. (52).

Simpson has noted that some varieties of apples are more subject to the attacks of the moth than others, and prepared a list showing their relative susceptibility: (32).

Pewaukee (always badly infested).
Red Astrakan.
Bellflower varieties.
Spitzenburg.
Grimes Golden, Northern Spy, Gravenstein.
Wealthy.
Baldwin.
Ben Davis (very variable).
Rome Beauty (variable).
Johnathan.
Winesap (always least infested).

It appears that the earlier apples are among the first on the list. Simpson has suggested that they may prefer

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the earlier varieties, because they are riper and more fragrant at the time of attack. It is probable, that although the insect has preferences, it would not disdain a greener apple, if no other could be had.

Description:

In 1758, Linnaeus gave the insect the specific name of pomonella, and described it as follows: "Alis nebulosis postice macula rubra aurea." (4). Its generic place has been the subject of controversy, but the genus Carpocapsa and species pomonella was sanctioned by August Busck, of the United States Department of Agriculture, in 1903, after his investigations, and this name has been accepted by practically all authorities. (33).

Kellog describes the moth as having "fore wings marked with alternate, irregular, transverse, wavy streaks of ask gray and brown, with a large tawny spot on the inner hind angle, and hind wings and abdomen light yellowish brown with a satiny luster". (42)

History and Distribution:

The original home of the insect was doubtless southern Europe, but it is now known almost the whole world over. (55). When the earliest discussions of its work in the United States were written it was already quite well distributed. For a long time its injury was thought to be due to the plum curculio, and this may be the cause of the obscurity of its early American history. In 1819, the codling moth was reared from wormy apples by Burrell. (32). Its history and distribution are practically the history and distribution of the apple. Cato mentions its work in his treatise on agriculture, written nearly 200 A. D.,

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and from 1635 when Goedaerdt first published an account of it, (1), until the present day almost every entomologist has studied it and written about it.

While some regions are doubtless less favorable there is no region where apples are grown which has proven immune to its depredations. In most of the districts which have at various times been reported as free from the pest it has since become troublesome, showing that isolation had been their only defense. It spreads so readily with infested fruit, in cracks of boxes or barrels, or even in freight cars, that its introduction into a new territory seems only a matter of time.

Life History:

Emergence of overwintering moths and egg stage.

In the spring the pupæ emerge as moths and shortly after the eggs are deposited singly. The egg is a flat somewhat oval-shaped object with a flange around it. It varies in size from .96 mm. to 1mm. by 1.17 to 1.32 mm. Commonly speaking it is about the size of a pin head. The surface is covered with a network of ridges which are much closer together toward the central portion than around the edge. (32). When first laid it is a pearly-white color. Later there appears upon it a faint red ring, marking the position of the forming embryo. A day later this ring becomes more distant, and disappears, and in its stead there is a dark central spot, produced by the black head and cervical shield of the embryo. When the larva leaves the egg the remaining shell appears like a fresh egg, except that it is very flat, and along one side the slit from which the larva made its exit can usually be seen. (30).

The early writers stated that the eggs were laid

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in the stem end or in or about the calyx end of the apple. They had never seen the egg, but reached this conclusion because of the position of the entrance holes of the larvae. "In 1889, Koebele & Weir stated that the eggs are laid at any point upon the apple, and are, as a rule, laid elsewhere than within the calyx.' Washburn, in 1892, found that the eggs were placed on both sides and top of the fruit." (17). In the spring of 1893, Slingerland reported that in confinement the moths laid eggs on the sides of the cages, on the leaves, and on the bark. (23). Card, in 1897, found that the eggs were laid almost exclusively upon the upper surface of the leaves. (24). Sanderson writes: "The eggs are laid on the fruit in this locality. An examination of about seven hundred eggs in the orchard shows that they are on the upper and under side of the leaves, but that on some varieties there are a larger number on the upper side, and on others more on the under surface." (43). Professor Cooley observes eggs on both leaves and fruit, with the preponderance throughout the season on the fruits. (34).

The diversity of evidence in these reports may be due to the fact that observations were made upon different generations. Professor Cordley suggests, that the moth does not lay eggs upon the young fruit because of the pubescence which is afterwards lost. (32). C. B. Simpson, after considering the experiments of others, and his own work in Idaho, inclines toward Professor Cordley's explanation, and concludes that "the eggs of the first generation are for the most part laid upon the leaves, while the majority of those of the second brood may be found upon the fruit." (32).

Many writers have stated that the oviposition oc-

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curs at night. The only reports of persons, who have actually seen the operation, place it during the early afternoon or early evening. Professor R. A. Cooley saw a moth deposit an egg in Missoula on October 4th, at five-forty P. M. (34). C. B. Simpson observes that the oviposition for the most part is accomplished in the afternoon or early evening, only one being observed during the forenoon. (32).

Owing to the great difficulty in making observations, there is very little definite information on the number of eggs laid by one female. The following data has been secured:

TABLE "A".

DATA ON A NUMBER OF EGGS.

Authority.	Observations.	References.
Le Baron.	Average of 50 eggs in ovary of female at time of emergence, and adds, that if all undeveloped eggs came to maturity this number must be increased.	(32).
Cooke, Matt.	One moth laid 85 eggs in a vial.	(32).
Simpson, C. B.	21 eggs before moth escaped from vial.	
	35 eggs before moth was killed by spider.	(32).
Gillette, C. P.	Eggs laid in confinement varied between 2 and 50.	(30).
Hammer.	Maximum number 91, average 35.8 (6 months).	(57).

Judging these statistics with reference to their relative value, a rough estimate of forty eggs for each female might be deduced.

Table "B" shows that the weight of authority places the period of incubation at about eight days. Jones and Davidson place the average at over twelve days, but their entire life cycle is longer than that determined by other workers. Cooley's data on incubation is for one egg only. The observation of Jenne, it will be noted, are at variance with the above con-

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clusions. He records the remarkable variation of from less than five to twenty-one days in the incubation period. The eggs requiring the longer periods were subjected to very cool weather, including frost. The eggs laid after the advent of warm weather required a period similar to that observed by other investigators. While these observations do not seem extensive enough to warrant any general conclusions, they are suggestive of the influence of climatic conditions on the development of insects, which, as will be discussed later, has a practical bearing on control.

Figures on the appearance of the red ring and black spot, though reported from only three workers, are the result of extensive observations. There seems to be a unanimity of evidence that the red ring appears in about 2.5 days and we can place the appearance of the black spot at 5 days after oviposition, although here again Jones and Davidson make a higher estimate.

Hammer found the average length of life of the winter brood moth to be 9.44 days, (57), Jones and Davidson 9.19 days, (62), and Washburn places it at 10 to 15 days, (17).

Larva:

From the standpoints of distribution, injury and control, the larval is the most interesting stage in the life history of this moth.

The writer has seen no larvae immediately after they had hatched, but found very young ones about 2mm. in length. They are a dull, rather transparent, whitish color, with a black head, black cervical shield and black anal shield. It somewhat resembles the plum curculio, but a hand lens will quickly reveal

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the distinguishing legs(three pairs of true legs, and five pairs of false or prolegs), and on the body the few short hairs arising from small, sometimes quite distinct dark dots.

The orchardist is much concerned with what the youngster does during the short time which elapses before he enters the apple. Simpson writes: "When hatched upon the leaves they may not find an apple for some time, and may subsist by eating small portions of the leaves. In confinement this often occurs, but it has never been determined accurately how often it takes place in the field. The writer has time and again noticed these spots on the leaves in the field, and has noticed also that larvae hatched on leaves would have to go from ten to twenty feet before they could find an apple." (32). Sanderson reports that, "The average distance of 588 eggs from the nearest apples on three trees in 1907 was 6¼ inches, while the average distance from the apples of 744 eggs on six trees during the past two years was nine inches, the average distance of eggs on each tree varying from two inches to twenty-eight inches. Eggs are quite commonly laid several feet from the apple, and indeed are quite commonly laid upon trees with no fruit at all." (43). "The young larvae feeds on the under surface of the leaves, mining into the mid-ribs and axils of the veins branching from the mid-rib and axils of the leaves." (43). These and other reliable observations establish the theory that the larvæ travel considerable distances and feed to some extent on the leaves, but the fact that in thousandsof orchards, sprays which have not reached the calyx cup have been economically unsuccessful, is an experiment on a vast scale which establishes with greater definiteness the fact that the leaf feeding is of very minor importance. It also seems strong evidence that it is

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by the calyx that most of larvae make their entrance. As this question of the mode of entrance is the keystone of the common control methods, it is worth consideration. Slingerland writes that, "75% or more of the young worms enter the fruit at the blossom end, and our observations indicate that they spend several days feeding around the calyx cavity." "Most of the young worms enter the fruit in the spring or early summer at the blossom-end. They either crawl between the calyx lobes or tunnel into the calyx-cavity at the point where the lobes join the surface of the fruit." (36). Gillette finds that out of 526 wormy apples examined 80% had holes at the blossom end. (43) Cooley reports 83% of first brood entering by calyx end. (34). Card writes: "Observations running through two seasons indicate that about 80% of the larvae hatched in the orchard have entered at that point" (the calyx cup). (25). The writer, in June, 1913, found only 22% of infested apples examined in Madison, Wisconsin, attacked at the calyx end. The above citations, with the exception of the last, show so striking an agreement of results, that we may safely assume that about 80% of the first brood of larvae enter by the calyx end. There is less evidence in regard to the place of entrance of the second generation, but Simpson states that it is for the most part on the sides of the fruit. Countings on 1,478 apples in September, 1902, showed only 27% entered by the calyx end, and Simpson estimates that fully 50% of the larvae entering at the sides enter where the fruits touch. (32).

Simpson has accurately described the work of the larvae in the fruit. After spinning a web over the hole the larva eats out a cavity under the skin and throws out but little castings. "This mine is eaten outwards from the point of en-

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trance, and in from three to five days the larva begins its tunnel toward the center of the fruit, reaching that point when about one-quarters grown and about a week old." (32).

"While at the surface, or while tunneling toward the center of the apple, the larva pushes the excrement and frass through the entrance hole. Later the entrance hole, especially at the calyx end, is enlarged, and a considerable amount of frass thrown out. When a considerable cavity has been made in the interior of the apples the excrement is bound together with silk. Upon reaching the central portion of the fruit the larva eats out an irregular cavity about the core, and seems especially partial to the seeds." (32).

The writer has found the full grown larva to be fifteen to twenty mm. long and usually of a pinkish color, especially on the dorsal side.

"When about full grown the larva makes a passageway to the outside of the fruit. This is usually towards the side of the apple, in a different direction from that of the entrance hole. Rarely does the exit passage follow along or consist of the enlarged entrance passage. Before the larva has passed outside, the outer portion of the passage is filled with a block of frass, or a cap of silk is spun over the hole." (32).

"When ready to leave the fruit the larva pushes out this block or tears away the cap of silk, crawls out on the surface of the apple, and immediately seeks a place in which to spin a cocoon." (32).

The injury of the larva to the fruit varies with the variety of the fruit and the brood of the insect. The "June drop" is the usual result of the feasting of the first brood, and

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many windfalls of later summer can blame the codling moth of the second brood as much as the wind for their downfall. Often the fruit remains on the tree and is picked for market, but if the larva has actually entered, it is useless for anything but cider. Indeed it is worse than useless, for if stored with other apples it soon rots, and becomes a source of contamination to the other fruit.

The number of stages through which the larvae pass is of interest to the scientist, rather than the orchardist. After very careful experiments, Jenne found several instars, (46), Hammer six,(57), Simpson five, (32), and some other variations are recorded. After considering the localities in which the investigators worked, there seems reason to believe that this is another of the factors influenced by climatic conditions. Molting is an arrangement for growth, and rapidity and amount of growth might easily be influenced by climate. Jenne, with the largest number of instars, worked in the south; Hammer, with six, in Michigan; and Simpson, with five, in the northwest where the seasons are short and the nights cool throughout the summer.

In estimating the time spent by the larva in the fruit, and the period of pupation, rather than basing conclusions by striking an average between the wide variations recorded in the chart, it seems more satisfactory to accept the figures of Hammer, (57), Gillette,(30), Simpson (32), and Slingerland, (32), who have done very careful work on the life history in the four important apple sections, Michigan, Colorado, the Northwest and New York, and who agree in placing the feeding period at about nineteen days, and the cocoon stage at about eighteen days.

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Cocoon:

The cocoon may be found in any protected spot, as in holes or cracks in the tree, under rough bark, or in cracks in the ground around the tree. If conditions about the trees are unfavorable, or if the fruit, or later the emerged larva, fall to the ground, the cocoon is spun in fence posts, in piles of rubbish, under clods of earth, or in the fruit (in a few recorded instances). The cracks and angles of packing houses, and boxes or barrels used for storage are common refuges for the pupating insect.

Simpson writes: "When a suitable place has been found for the spinning of a cocoon the larva begins to weave about itself a single thread of silk. The exterior outline of the cocoon conforms to that of the cavity or crack in which it is placed. While spinning the larva is bent upon itself and decreases considerably in size. When the cocoon is completed, which takes usually about one day, the larva straightens out and contracts in length. While the exterior of the cocoon may be rough, the interior is always smooth and oval in shape. At completion of the spinning of the cocoon the alimentary canal, silk glands, and other organs peculiar to the larva, begin to disintegrate." (32).

The summer cocoon is larger and more primitive than the winter cocoon which is completely sealed, and consists of heavy walls for protection. When not limited by the surroundings they tend to be oval, but usually the larva is forced to conform his work to the limited space.

Hammer writes: "A slight depression is made in the bark, the walls along the exposed sides are constructed from fragments of bark held in place by silken threads, and the inside is

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finally lined with a thin layer of silk. Within the small space of the cocoon the larva will be found in a doubled up position. In the spring previous to pupation, the winter cocoon is partly remodled by the larva, and provision is made for the issuing moth by the addition of new fragments of bark. Depending upon the location of the cocoon the exit tube varies in length from ¼ to over 1 inch. The purpose of the tube must be to provide a safe exit at the critical period of the emergence of the moth. Within the cocoon over the opening to the exit is placed a thin sheet of silk which is ruptured by the pupa at the time it wriggles out to give issuance to the moth." (57). The larvae of the first brood also make their cocoon with an exit tube.

Slingerland states that, "After the pupa has thrust itself out of the cocoon, the pupal skin splits down the back, and the moth forces its way out by splitting away the head end of the skin." The adult is seldom observed because of its color protection, and even when disturbed flies so quickly and erratically that it is soon lost among the foliage. (33).

Number of Generations:

The second generation inflicts more damage than the early one; First, because they are more numerous; and secondly, because the fruit is more mature, artificial thinning has been completed and injured fruit is a clear loss. It is, therefore, valuable to ascertain the number of generations in a given locality.

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TABLE "C".

Authority.	Reference.	Locality.	No. Broods.	Zone.
Colling,	56	England,	1	
Goedaerdt,	1	Northern Europe,	1	
Rosel,	3	Northern Europe,	Unindicated,	
Pissot,	14	Southern Europe,	2 Indicated,	
Raemur,	23	Southern Europe,	2 Indicated,	
Atkins,	25	Maine,	1½	Transitional.
Gillette,	30	Colorado,	2	Transitional.
Cooley,	34	Montana,	2	Transitional.
Koebele,	13	Santa Cruez Mts., Cal.,	2½	Transitional.
Sanderson,	43	New Hampshire,	2 Indicated,	Transitional.
Hammer,	57	Michigan,	2	Transitional.
Jones and Davidson,	62	Santa Clara Valley, Cal.,	2	Transitional.
Fletcher,	33	Ottawa, Canada,	1	Boreal.
Fletcher,	32	Ohio,	2	Transitional.
Cordley,	29	Corrvallis, Ore.,	2	Transitional.
Washburn,	17	Corrvallis,	4	Transitional.
Smith,	20	New York,	1	Upper Austral.
Sanderson,	32	Delaware	1½	Upper Austral.
Trimble,	6	New Jersey,	2	Upper Austral.
Le Baron,	9	Northern Ill.,	2	Upper Austral.
Riley,	32	Missouri,	2	Upper Austral.
Popence and Marlatt,	12	Kansas,	2	Upper Austral.
Gillette,	15	Iowa,	2	Upper Austral.
Walton,	32	Iowa,	2	Upper Austral.
Riley,	18	Maryland,	2 Indicated,	Upper Austral.
Melander,	53	Washington	2½	In a narrow arm of U. A.
Aldrich	31	Lewiston, Idaho,	2½	Upper Austral.
Card,	25	Nebraska,	3	Upper Austral.
Jenne,	46	Arkansas	3	Upper Austral.
Coquillett,	17	California,	3	T, U.A.& L. A.
Cockerell,	21	Mesilla Park,	3	Lower Austral

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Table "C" shows the results of a number of investigations in the number. The milder districts would be found to produce most abundantly, and this is evidently the case. It has been suggested that there might be a relation between the number of generations and the "Life Zones" of the Biological Survey mapped out by Merriam. (27). To throw light on this phase of the question the localities in the United States from which reports are tabulated have been arranged by zones. The table indicates that there is one brood in the Boreal, and two throughout the Transitional and most of the Upper Austral, with a third, or at least a partial third, in some parts of the Upper Austral and Lower Austral. The only striking variations are the conclusions of Smith in New Jersey, whose figure is thrown in doubt by contradictory results secured by other investigators in the same region, and evidence of Washburn of Oregon, who, there is reason to believe, means not four generations but four broods, and but two complete generations.

This question of the number of generations is still much in dispute, but we can certainly assume that there are two distinct generations throughout the principal apple growing districts of the United States, and that a third generation, if present at all, does not materially affect practical control methods.

Summary of the Life History:

If we correlate the conclusions deduced from the evidence presented in this paper, we find the life cycle of the codling moth to be divided approximately as follows: Incubation period 8 days; feeding period 19 days; entire cocoon stage 18 days; time from the emergence of the moth to the egg laying period 6 days; making a total of 51 days. Gillette of Colorado

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estimates 49 days, (30), Hammer of Michigan determined an average of 51.6 days in 1910, and 51.1 in 1911, (51), Simpson figures on 55 to 58 for the Northwest.(32). Thus a total of 51 days is doubtless within a few days of the truth.

Throughout the discussion no definite dates have been set for the occurance of the stages in the life history. A glance at Table "B" will make the reasons for this evident. Emergence of the spring moths has been reported from March 24th to June 24th, and the later stages show even greater variations. It is clear that not even approximate dates can be set which will be true for all climatic conditions. Professor J. G. Sanders has suggested the value of relating the periods in the cycle of the insect with some easily observed seasonal development of a plant. The data collected in the paper points clearly to the influence of environment on the various phases of the moths life history, and it is reasonable to suppose that conditions of moisture, temperature, etc., which apparently hasten or retard plant growth, will govern the progress of the insect in some related way. With this in mind, the available literature has been reviewed to secure pertinent data.

Hammer writes that in Michigan, " The time of emergence of the earliest moths has closely followed the time of blossoming, and occurred from 5-10 days after the blossoms dropped (Baldwin apples). By adding to these figures the time of flight of the moths previous to oviposition, and the time of incubation of the eggs, it was found that fully three weeks elapsed before the hatching of the earliest larvae of the first brood." (57). Simpson reports from Idaho: "We find the moths may emerge some time before the apples are in bloom and, depending largely upon

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locality, the larvae begin to enter the fruit from a week to two months after the blossoms have fallen." (32). Slingerland states that the moths begin to emerge, in New York, about the time the apples are in bloom, but the majority do not emerge until after the blossoms fall, and but few larvae are found to enter the fruit until about two weeks later. (26). Gillette, in Colorado, found the first moth emerging about ten days before the trees are in bloom. He states that the majority of them emerged about the time of bloom, but the eggs were found July 9, 1900, and June 19, 1901, and were all hatched by June 21st, the trees having been in blossom about May 5th to 15th. (30). Card found the eggs about three weeks after the blossoms had fallen. (25). Cordley found that in Oregon the first larva entered thefruit about July 1st, the egg from which it hatched probably having been deposited about June 21st. Thus, the entering of the fruit took place about two months after the petals had fallen. (29). Simpson found that in Southern Idaho the apples in 1902 were in full bloom about May 13th, and the first larvae noted to have entered the fruit about June 11th, or about twenty-five days after the blossoms had fallen. (32).

Though not so conclusive as might be desired, we can assume from these observations from widely separated regions that the majority of moths emerge very shortly after the blossoms fall, and the larvae enter the fruit two weeks to a month later. This second date is the important one in a program of control. Another very important period from the horticulturist's standpoint is that during which the second brood enter the fruit, but unfortunately no investigator seems to have studied this in the

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light in which we are interested. The importance of relating this to some regular seasonal event will be apparent when control measures are considered.

Control:

For convenience, the control may be considered under three heads, preventive, general cultural and remedial measures, and spraying.

Preventive:

In the control of this pest too much reliance should not be placed in efforts suggested by this first head. There are doubtless a few peculiarly isolated orchards from which the insect can be excluded for many years, perhaps, permanently, but in essentially all cases even the exercise of great care will not insure complete immunity. The practice of having old boxes or barrels returned for refilling purposes imposes an avoidable risk, but most of the avenues of infestation are beyond practical control. The larvae are not introduced with nursery stock, except in rare accidental cases. Professor Cooley says that he believes its arrival into some of the apple growing districts of Montana has been delayed to a worthy extent by the inspection of imported fruit. (59).

General Culture:

As in most pest campaigns, cultural practice is an important supplement to more specific measures.

Trees should be headed low, planted reasonably far apart, and kept open enough to expedite spraying.

All roughness, cracks or cavities on the trees, or rubbish about the orchard, in which the cocoons might be protected, should be avoided. There is no more persistent enemy

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of the codling moth than some of our birds, and every effort should be made to reneder their work easier by forcing the larvae to spin their cocoons in exposed places. Observers have alsc found that mortality from cold is much higher among the larvae hibernating in unprotected places.

Forbes and Munson have shown that about 82% of windfalls are caused by the codling moth, and observations of Le Baron, Beal and Cook led them to conclude that about one-half the wormy apples which fell still contained worms. (36). Plainly, then, a destruction of the windfalls would destroy large numbers of the pest. No experiments have been made to test the ecconomic factors entering into this practice. Probably the labor required would bring larger returns if directed toward greater thoroughness in spraying. Hogs or sheep have been used to clean up windfalls satisfactorily. In this connection mention should be made of the advisibility of having fruit stored in a house which is tight enough to permit fumigation, or, far better, in a building which is screened to prevent the escape of any moths which develop from larvae carried in the fruit. In California Mr. De Long kept record of the moths which emerged in an apple storehouse, and reports that 11,974 moths were killed from April 15th to August 13th. (32). This is certainly strong evidence in favor of screening.

The first specific remedy was suggested by Burrell of Massachusetts who writes that thousands of insects may be obtained "by winding round or hanging any old cloth in the crotch of the trees, from the time they begin to leave the apple till the time the fruit is gathered. I think at present the best remedy would be this: In the fall when the insect has crept

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into the cloth for winter quarters take the cloth from the tree, and put them into an oven hot enough to destroy them." (5). Almost twenty years later Dr. Trimble devised his famous "Hay-Rope Band." (6). Riley, in 1869, recommends this as the best remedy, and lays down the following rules: "First, the hay-band should be placed around the tree by the first of June, and kept on till every apple is off the tree. Second, it should be pushed up and down, and the worms and chrysalids crushed that were under it every week, or at the latest every two weeks. Third, the trunk of the tree should be kept free from old rough bark, so as to give the worms no other place of shelter, and fourth, the ground itself should be kept clean from weeds and rubbish". (8). No improvement can be made on the rules to-day, as far as efficency is concerned, though bands of heavy paper, burlap and similar material have largely replaced the hay, but only because of greater ease in handling. Later workers are tending to lay emphasis on thoroughness in the one particular remedy, spraying. It seems that the labor which it is profitable to employ can best be applied in this way. For this reason banding has been abandoned by most orchardists. It is, however, an efficient method which may still be wisely employed in old, badly infested orchards for a few years to supplement spraying, but never as a substitute for it.

Spraying:

It was not until 1878 that the most effective remedy was discovered by accident. E. P. Haynes, a practical fruit grower of Niagara County, New York, on the advice of J. S. Woodward, sprayed his trees with Paris Green for canker worm, and found that it also checked the codling moth. This fact was re-

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ported to the Western New York Horticultural Society by Mr. Woodward. (36). The first careful experiments were conducted in 1880 by Cook of Michigan with positive results. (10). Careful and extensive experiments by others confirmed his conclusions, but it was not until 1888 when the establishment of the state experiment stations offered a reliable means of advertising it in every section of the country, that it was generally adopted. It has now become a routine practice, one of the fixed costs of business, in all successful orchards, and has really made possible the production of high grade apples.

As the larva has biting mouth parts, a stomach poison is used. Arsenic is the active constituent of all the commoner poison sprays. Scheele's Green, a compound of arsenic and copper is but little manufactured. London Purple, a waste product in the manufacture of aniline dyes is too variable in composition to be recommended. Paris Green, a definite chemical compound of arsenic, copper and acetic acid, is probably the most generally known, but arsenate of lead has, during recent years, been adopted in many of the larger commercial orchards. The lead compound is a little more expensive than the Paris Green, but it does not settle so rapidly and adheres to the foliage longer. Also, Paris Green contains so much free arsenic that it is always wise to add lime to counteract the burning effect, while with arsenate of lead this is not necessary. The former is prepared with one pound of Paris Green and one to two pounds of lime to 100 to 350 gallons of water, (32); and the latter, by adding one to three pounds of the arsenate of lead to 50 gallons of water. Arsenate of lime is another spray which does not seem to be used as generally as its merit warrants. Simpson is among

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those who report having used it with unvarying success, and find it cheaper than the arsenate of lead. (32). Scott and Seigler have just completed tests which they believe show that lime sulpher has a decided value as a stomach poison. (63).

It is often desirable and practicable to use sprays which combine both fungicidal and insecticidal qualities. Practically the entire expense of spraying is in the application, the cost of the materials being relatively unimportant. Thus, if we can combine our campaign against our insect and fungus enemies, we can almost reduce our expense by half. Since recent demonstrations have shown that lime sulphur, which has long been known as a contact insecticide, has fungicidal qualities nearly equal to those of Bordeaux, it has become deservedly popular as a material to be combined with arsenate of lead or Paris Green. From this mixture we have a spray which acts as a fungicide, a contact insecticide and a stomach poison.

In all spraying operations, making the application at the right time, is a "sine qua non" to success. The program for the control of the codling moth is to place some poison in the calyx cup of the apple before it closes, so that the large number of larvae who make their first few meals at that point will include arsenic in their menu, to apply a second time when the eggs are hatching, and a third time when the second brood of larvae appear.

The later sprays are made with reference to the life cycle of the insect, but a proper application of the first requires an understanding of the development of the fruit. Slingerland was the first to throw light on the principles involved in the calyx spray. Previous to his work, the orchardists had suc-

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cessfully applied poison at the time the petals were falling. When further investigation showed that the larvae to be poisoned did not appear until over a week after the falling of the blossoms, the advisability of the accepted date for spraying was questioned. Slingerland then noticed that on most varieties of apples the calyx cavity closed, within a week or two after the petals dropped. Thus, by applying a poison at this time, we deposit some arsenic in the calyx cavity where it is protected until the tiny trespasser is ready to start on his feeding career. If the spraying were done at the time the larvae were arriving, the calyx cup would be closed, and the basin be turned down, so it would be practically impossible to get any poison to the desired spot. (26).

The more recent the investigation, the more emphasis does the investigator lay upon the last spray in stating his conclusions. All the available literature has been reviewed in order to secure the concensus of opinion on the very important problem of the proper time to spray. The results are tabulated in Table "D". It will be seen that only two men omit the calyx spray. One of them, Riley, wrote his report over twenty years ago, and Washburn's was submitted over ten years ago. Several advise this spray alone. The experiments of Quaintance and Scott are especially pertinent. Bringing together the results of all of the tests which represent several seasons and varied conditions, they report an average of 90.64% sound fruit from a single spraying as compared with 96.19% on plats receiving from three to five applications. The unsprayed plats showed an average of 57.79% of fruit free from codling moth injury. (58).

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TABLE "D".

Authority.	Ref.	Locality.	First.	Second.	Third.
Riley,	18	Maryland,		Week after petals fall,	
Washburn,	17	Oregon,		Quite a time after petals fall,	
Card,	25	Nebraska,	Calyx Cup,	June 1st,	June 15th.
Gillette,	16	Colorado,	Not later than one wk. after petals fall,	Later if it rains,	
Gillette	36	Colorado,	As soon as petals are fairly off,	1 week later,	July 4th.
Colling,	56	England,	Just when petals fall,	1 wk. later,	
Jones & Davidson,	62	California,	Shedding petals,	2 to 3 weeks later,	3 to 4 weeks after second.
Hammer,	57	Michigan,	Shortly after petals fall,	3 to 4 wks. later,	10 wks. later possibly 8 or 9.
Quaintance & Scott,	46	Va., Mich., Del. & Kan.,	As soon as petals fall,		
Cooley,	59	Montana,	Just after petals fall,	2 weeks later,	
Cordley & Jackson,	64	Oregon,	Just after petals fall,	June 25 to July 1,	4 or 5 weeks after second.
Scott & Quaintance,	39	Arkansas,	Just after petals fall,	3 weeks later,	6 to 7 weeks later.
Moore, J. C.,	48	Wisconsin,	Just after petals fall,	10 to 14 days,	
Lovett, A. L.	54	Okla.,	Just after petals fall,	10 to 15 days later,	
Norton and Norman,	49	Maryland,	Just after petals fall,	10 days later,	early in July.
Gossard, H. A.,	37	Ohio,	Just after petals fall,	7 to 10 days later,	Last week in July.
Henderson,	40	Idaho	When petals are falling,	8 to 10 days later,	
Slingerland,	26	New York,	Just after petals fall,	1 week later,	
Whitten,	22	Mass.,	As last flowers fall,	10 to 12 days later,	
Hammer, A. L.	50	Pa.,	Just after petals drop.	8 to 10 days later,	cir. August 1.
Beattie & Melander,	60	Wash.,	When last blossoms are falling,		

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In Professor Gossard's work in Ohio a single spraying resulted in 91.60% of sound fruit as compared with 45.80% from unsprayed trees. (44).

In West Virginia, Rumsey obtained by the one-spray method 97.40% of fruit trees from codling moth as compared with 96.7% sound fruit from four applications. In these tests the unsprayed trees showed 65.9% only of sound fruit. (51).

Dr. Felt, after experiments in New York, covering three years, shows for plats receiving a single application, 97.35% of sound fruit; for plats receiving three applications, 99.22% of fruits free from worms, as compared with 79.05% of sound fruit on unsprayed trees.

These results show that only slightly less efficiency can be secured from one spray than is possible from several. Probably one spray thoroughly done with high pressure will do the business, so that later ones are unnecessary, but neither one or many will prove satisfactory if carelessly done.

Like most questions in horticulture, the determination of number of sprays advisable must be finally determined by particular conditions. How serious is the infestation, how near and how careful are other orchardists, and how many broods occur, are some of the questions involved.

The timing of the second application is related to the appearance of the insect. While there are some variations in the dates tabulated, there is a reasonable unanimity in placing it at from one to two weeks after the first. In most orchards it takes several days or a week to cover the ground, and as a spray applied too soon may only be wasted, possibly, while one delayed until after the worm has entered the apple will

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certainly be lost, it will probably be safest to begin soon enough after the calyx spray to be through before two weeks, at the most, have passed.

The table shows the impossibility of setting a definite date for the third spraying. Each fruit grower must settle the question for his particular locality. The object of this part of the campaign is to poison the second brood of larvae, so a natural and safe method of determining the proper date is to rear some insects under conditions as nearly normal as possible. When our captive pupa emerge, we may know that it is time to put the spraying outfit in order. If, as has been suggested before, we could relate this stage in the life cycle with some seasonal development in a common plant, we would have an almost equally certain, and much more troublesome way of determining the time for the attack.

Other applications are sometimes made, but unless the arsenic is simply added to a spray, that would be given anyhow for another pest, there is little evidence to encourage it.

Natural Enemies:

Our most valuable allies in the war against the codling moth, are the birds. W. D. McAtee presented this phase of the question in concrete form. He reports that, "36 species of birds are known to prey upon the codling moth in the United States. These species belong to 13 families of which the most important, so far as number of species on the list is concerned, are the woodpeckers, titmice and sparrows. Especially valuable species are the downy woodpecker, Bullock oriole, black-headed grosbeak, and brush tit." (55). The most valuable birds are

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those which are accustomed to obtain their food from crevices and under bark flakes, for they can capture the larvae during the winter. One of the best evidences of the efficiency of birds is the great scarcity of intact hibernating cocoons and the abundance of empty ones which have evidently been rifled by birds. Long ago Walsh and Riley wrote: "From the careful inspection of several large orchards in the early spring months, we are convinced that almost all the cocoons of the apple-worm moth, that have been constructed in the autumn on the trunks and limbs of apple trees, are gutted of their living tenants by hungry birds long before the spring opens." (41). Buck, in Virginia, writes that, "Counts of over 400 cocoons observed on apple trees revealed the fact that birds had destroyed fully 85% of the worms." (45). From New Hampshire, Sanderson reports: "Only 5 to 30% of the larvae survive the winter. An examination of seven trees, which averaged 38 cocoons per tree in the fall, showed but 5% alive in the spring, 87% having been killed by birds, 4% by disease, and 3% by cold. In another orchard, 1,096 cocoons were examined in May, 1907, with 19% alive, 66% having been killed by birds, 6% by disease, and 9% by cold." (47).

Invertebrate Enemies:

Simpson has compiled the following list of invertebrate enemies of the codling moth: (32).

Chauliognathus pennsylvanicus.

Chauliognathus marginatus.

Telephorus bilineatus.

Trogosita corticalis.

Trogosita laticollis.

Trogoderma tarsalis.

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Perimegatoma variegata.

Pterostichus californicus.

Calathuis rufipes.

Dermested.

Clerid.

Chrysopa.

Raphidid.

Gonizus sp.

Macrocentrus delicatus.

Pimpla annulipes.

Bethylus sp.

Hypostena variabilis.

Though the names of the parasites make a rather formidable looking list, it is doubtful if their combined attacks destroy many of the codling moths, except in orchards where the pest is so abundant that the apple crop would be ruined in spite of the destruction of even a considerable number of the moths. The idea of a natural control of this orchard enemy is very attractive, but an insect which is so wide-spread offers little hope to experimenters along this line.

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NO	AUTHORITY	REF.	LOCALITY	EMERGENCE	OVIPOSITION
1	F.T. Washburn	17	Oregon	June 1	June 11
2	T.D.A. Cockerell	30	Mesilla Pk N.M.	April 2 - first	May 4 - first
3	Silmon Smith	30	Grand Junc. Col.	May 7 - "	May 18 - "
4	H.H. Griffin	30	Rockyford Col.	May 10 - "	
5	R.J. Peore	30	Canon City Col.	May 5 - "	
6	J.B. Smith	30	N. Brunswick N.J.		
7	A.D. Hopkins	30	Morgantum N.Y.		
8	M.V. Slingerland.	23	Ithaca N.Y.	May 3 "	June 26 - "
9	F.W. Card.	25	Lincoln Neb.	May "	June 1 - "
10	David Bros	30	Denver Col.		
11	C.P. Gillette	30	Ft. Collins Col.	May 5 "	June 9 - "
12	C.V. Riley	8	St Louis Mo.	May 7 "	
13	N. Le Baron	30	Northern Ill	May 12 "	
14	Washburn & Cordley	30	Corrallis	May 16 "	June 20 - "
15	E.P. Taylor	30	Ft. Collins Col.		
16	Roesel	3	Germany		
17	Cooley R.A.	34	Montana		June 18 "
18	Collings	56	England	End of May	Just after petals fall
19	Riley	18	Maryland		
20	Jenne	46	Ozark Mts.	Full bloom 3/31 to 5/31 first	
21	Koebele	13	Alameda Cal.	4/22 to 5/10	
22	Hammar	57	Mich. 1909	June 17-24 max	
23	"	57	" 1910	" 18-30	3-15 days after emmergence
24	"	57	" 1911	" 20 to 25	6/25 to 7/3
25	Jones & Davidson	62	Santa Clara Co. Cal.	4/17 to 5/17	
26	"	62	" 1910	3/31 to 6/20	4/10 - 6/20
27	"	62	" 1911	3/24 to 6/20	
28	Henderson	40	Idaho	When petals are falling	1-2 days after emmergence
29	Sanderson	43	Durham N.H.		
30	J.S. Birge	—	Madison Wis.		
31	Riley	7	Missouri	May 1	
32	Simpson	40	Idaho		
33	Hammer	50	N.N. Pa.	6/15 to 7/15	

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NO.	APPEARANCE OF RED RING	BLACK SPOT	HATCHED	INCUBATION	LEAVING FRUIT
1			June 21 1st	5-10 days	July 19
2			May 31 "		
3			June 5 "		
4			June 15 "		
5			June 15 "		
6			July 20 "		
7			July 20 "		
8			July 1 "	7 days	
9			June 20 "	8-10 days	
10			July 3 "		
11			June 28 "	6-8 laboratory	
12			June 23 "	4-10 days	
13					
14				5-6 days	
15	2nd-3rd day	4th-6th day	5th-6th day	7 in field	
16				8 days	
17				11 laboratory	
18				7-8 days	
19					
20	18th day	16th day	4/27 to 5/27	5-21 days	July 15 last
21					
22				5-21 days	
23	2-3 days after oviposition	1-2 days previous to hatching		6-7 days	
24	2-4 days after oviposition	3-9 days after oviposition	July 6-11	4-10 " total	7/20 to 7/25
25					
26	2 to 5 average	8-9 average	4/20 to 7/10	12.4 average	
27	3 days	11 days		12.77 "	
28				8-10 days	
29				9-10 days	
30					July 31
31					6/5 to 6/10 1st
32				11 days	
33	3 days	5-6 days	6/25 to 7/25	7 days	

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NO.	PERIOD OF FEEDING	PUPATION	SECOND BROOD MOTHS	EGGS	LARVA
1	28 days				
2			June 26		
3			" 28		July 23- 1st
4			July 5		Aug. 6 .
5			" 15		" 1
6					
7					
8	20-30 days				
9	10-14 days		July 2		Sept. 5
10					Aug 3
11	19 days		" 13		
12	25-30 days outside cocoon	12-18 days	" 8		
13			" 15		
14			Aug. 1.		
15					
16					
17	24 days	14 days			August 10
18	20-30 days				
19	about 1 month	12 days			
20	23.8 average	16.75 average in cocoon		June 13 1st	June 18
21			August 13		
22			" 3		
23		13.6 average	" 22	3-7 days after emergence	7.5 days 9/10 max.
24	21.75 average	14 "	" 19-24	8/27 to 9/3	9/7- 9/12
25					
26	38.1 "	19.04 "	7/8 to 9/22	7/9 to 9/25	
27	25.8 "	23.12 "	7/22 to 9/29	8/- to 9/-	8/- to 9/-
28	18-20 days	20 days			
29	31.7		8/8 to 8/23		
30					
31					
32	20 days	21 "			
33	26 days	12 days	8/1 to 9/1		

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The Lesser Apple-Worm, Enarmonia prunivora, Walsh.

There are several other Lepidoptera that cause more or less injury to apple trees. These, and the important pests in other orders will be considered, though the scope of this work will not allow them the detailed discussion given to the codling moth.

History:

While the work of the apple-worm is fresh in our minds, the lesser apple-worm, Enarmonia prunivora should be noticed. This species was discovered by Walsh in Illinois, in 1867, and though it received mention from a number of writers, attracted little notice and was given no careful study until quite recently. This is doubtless due to the fact that it was confused with the codling moth. Quaintance, however, reports that it ranks as an apple pest close to the codling moth.

Distribution:

It is a native of the United States, and is reported from all districts in the Mississippi Valley eastward, and up into Canada. Though originally feeding on cretagus and wild crab, it has been bred from plums, prunes, cherries, galls and apples.

Life History.

The winter is passed by the full-grown larvae in cocoons in protected places, and pupation occurs in the spring. They probably emerge about the same time as the codling moth. (3). The parent insect, which is a small moth, oviposits soon after the fruit sets. Injury to the fruit by this brood is apt to take the form of small cavities eaten into the surface at the calyx end. (3). The first brood often pupate in the calyx end

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of apples, or in plums, after these have fallen to the ground, in small withered apples, or in protected places about the tree. The second brood larvae may penetrate the pulp to a depth of half an inch or more (3). Quaintance has noted important injury having been done after the fruit has been barreled. (2). The full-grown larva is about one-quarter inch long.

Control:

Experiments and observations by the United States Bureau on Ent. in Nebraska, the Ozarks in Virginia, show that spraying with arsenicals for the codling moth is also effective in controlling to a considerable extent, the lesser apple-worm.

Canker Worms.

Common Characteristics:

Shortly after the apple tree has put forth its leaves in the spring, large numbers of a slender, naked, measuring worms appear on this and other trees. As they increase in size, they devour the entire leaf with the exception of the mid-rib. Two different species are concerned in this destructive work, the fall canker-worm and the spring canker-worm. The latter can be readily distinguished for it possesses only two pairs of legs on the under side of the posterior half of the body, there being three pairs in the species first mentioned. Both are evidently natives of this country, and have never been reported as occurring outside of America.

The Spring Canker-Worm, Paleacrita vernata, Peck.

Distribution:

The species occurs from Maine to Iowa, and southwest to Texas. As the adult female is wingless, its spread is necessarily slow, except rarely through the medium of nursery

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stock infested with eggs.

Life History:

When full grown the worms enter the ground, and remain there until the following spring. In this stage, clean cultivation will destroy them. The adults come out several weeks before the apples are due to blossom. The female crawls up the trunk and lays her eggs which somewhat resemble in miniature those of a hen, and are placed in irregular masses, usually concealed beneath pieces of loose bark, etc. The egg hatches after the apple leaves have unfolded. (1) (3).

The Fall Canker-Worm, Alsophita pometaria, Harr.

Life History:

In this species the larva also enters the soil to transform, but the adults emerge in the fall instead of the spring. The female, which, like that of the spring species, is wingless, immediately climbs the trunk and oviposits. The eggs somewhat resemble miniature flower pots. They are attached to the bark in masses of from sixty to one hundred placed side by side in exposed situations. Hatching occurs about the same time as with the preceding species, and the worms attain their full growth and enter the earth at about the same time, but instead of simply lining their cells with a few strands of silk, they spin dense cocoons of a yellowish silk which makes them less at the mercy of the cultivator. The change to the chrysalis takes place about one month after the spinning of the cocoon, and the adults issue, for the most part, from the middle of October through December. (1) (3).

Control:

Spraying with arsenicate will control the canker-worms, but it should be applied early because the young larvae are

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more sensitive, and because if applied late, serious injury may havebeen done before the poison takes effect.

Banding with Tanglefoot, or some other sticky substance is sometimes used, but is expensive, and in most orchards, where the regular spray calendar is used, it is useless.

Apple-tree Tent Caterpillar, Malacosoma americana, Fab.

Superficial Appearance and Life History:

The eggs of this insect may be seen encircling a twig in a compact mass. The caterpillars hatch as soon as the foliage is out. They are about two inches long. The body is black, ornamented with a well defined white line down the middle of the back, and with a row of blue spots along each side. On the apple, wiled cherry, and other plants, it forms a conspicuous web in the fork of smaller branches, the caterpillars spending part of their time on or in this nest, and going out from it to strip the leaves. The adult is a dull reddish-brown in color.

Control:

They are easily controlled by an arsenical, or by burning the web in the early morning or during cloudy weather when the caterpillars are at rest. (3) (4).

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COLEOPTERA.

The Round-headed Apple Tree Borer, Saperda candida, Fab.

Importance:

The round-headed apple tree borer is one of the worst enemies of the American apple grower. It is a native of America, where it is a menace to pomaceous trees in practically every state east of the Rocky Mountains.

Life History:

The adults, which are handsome, stripped beetles , nearly an inch long, emerge late in May and in June, according to locality, coming forth during the night from the trunks of the trees in which they have pupated. Soon the sexes mate and eggs are deposited. "The female first make an incision in the bark, whether by means of her mandibles or ovipositor, is not plain, causing it to split slightly, then turning her head upward, places an egg under the bark nearly a quarter of an inch from the incision, accompanying the deposition by the extrusion of a gummy fluid which covers and secures it to its place, and usually fills the aperture." (1).

The only information on the period of incubation is that of E. W. Junkins who observed an egg which hatched in twenty-two days. (1).

The larvae requires three years for maturing, feed-

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ing first in the sapwood, but later penetrating to the heart of the tree. The grub, which is then an inch long, yellowish-white, with a small, dark head, and slightly enlarged, brown, first sedment, gnaws outward, and with its head pointing toward the bark, forms a pupal cell. Chittenden places the pupal period at about nineteen days, after which the mature beetle cuts its way out, leaving a round hole.

Control:

The oldest, and probably the surest way, of destroying the larva is to cut them out with a knife or draw them out from their burrows by means of a soft copper wire. The objection to this system is that the knife may do as much damage as the insect, and that it requires considerable labor. However, if one can learn to detect their work promptly, these disadvantages can be reduced to a minimum.

Wood veneer, paper, wire gauze or mosquito netting may be tied around the trunk from two to three inches below the ground to a height of three feet to prevent egg-laying.

Pure white lead and linseed oil may be painted on the trunk, or if renewed occasionally, protective washes may be used as deterrents. Whitwash and lime sulphur has also been recommended.

If kerosene is applied freely wherever the castings of the larva are seen protruding through the bark, it will carried by capillary attraction, permeate the entire burrow where it comes in contact with the larva, which soon succumbs. (1).

Again, emphasis should be laid upon the importance of clean cultural practices. Weeds should be kept down, and rubbish removed, and trees, infested beyond recovery, burned.

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The Flat-headed Apple Tree Borer, Chrysobothris femorata, Fab.

Superficial Appearance and Life History:

This more abundant, though less dangerous, borer is a member of the family Buprestidae. The active metalic colored beetle about one-half inch long emerges about the same time as the round-headed borer, or later, and oviposits during June and July. This species is not restricted in its ravages to fruit trees, but attacks, also, a number of deciduous varieties, always preferring weakened trees. It is a great lover of sunlight, and practically exclusively deposits its eggs in places exposed to the sun.

The grub has a flattened and enlarged segment just back of the head, and lives for the most part beneath the bark, though sometimes entering more deeply into the sapwood. It works higher up the trunk than does the round-headed borer. This species requires only a single year for its development, pupation (which takes about three weeks) occurring in the early spring. (3). The exit hole distinguishes its work from the round-headed borer, being elliptical instead of round.

Control:

The remedies advised for the round-headed borer are also effective against this species. It is necessary, however, that washes, etc., be applied to the main branches, as well as the trunk. Cultural carefulness may yield even greater rewards.

The Shot-Hole Borer, Scolytus rugulosus, Batz.

History:

The shot-hole borer, or fruit tree bark-beetle,

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is an immigrant from Europe, and was first noticed in this country in 1877. Probably, through the medium of nursery stock, it has now spread thoughout most of the east and middle west, and is now a serious pest on plum, peach, cherry, apple, pear and other varieties. It much prefers weakened trees.

Life History:

From May to June, according to the season and locality, the beetles appear and begin to burrow through the bark. "After penetrating the sapwood, feeding as she goes, the female constructs, partly within the bark and partly in the wood next to it, a vertical gallery or brood chamber, and along the sides of this at very short intervals gnaws little pockets in which she deposits her eggs. The minute, whitish grub-like larvae hatching from these eggs excavate little side galleries, which start at right angles to the brood chamber, but soon diverge and widen with the increase in the size of the gnawing larva." (2). "Completed main galleries measure from one-half to two inches in length and the average number of eggs deposited in each by a single female is said to be about 80." (2).

"The parent beetle, according to the studies of Dr. J. B. Smith, at New Brunswick, New Jersey, occupies less than a week in the construction of the brood chamber, the eggs hatch within three days, and the larva is about twenty days in attaining maturity. When about to transform the larva forms, at the large end of its gallery, an oval chamber, usually in the wood, but sometimes partly in the bark, and here the pupal stage is assumed." (2).

In northern sections there are probably two generations each year, in the south, three.

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Control:

A number of parasites are very effective in holding this borer in check.

Cutting out is useless against this species, and, indeed, it is difficult to treat it in any way, because of its minute size, extreme abundance, and the fact that it is not restricted to any portion of the tree, and that oviposition occurs throughout the season.

Clean culture is of prime importance, for the insect breeds in large numbers in dead or dying trees and brush piles. Deterrent washes may also be used, and trap trees and branches have been successful in limited trials.

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Plum Curculio, Conotrachelus nenuphar, Herbst.

The suborder Rhynchophora, or snout beetles, includes several of our most expensive insect pests. The one of most importance to fruit growers is the plum curculio.

History:

No insect received earlier attention from American horticulturists than this curculio. Writings in the early part of the eighteenth century indicate that it was already common. Investigations by the Bureau of Entomology have shown that it is confined to the humid regions of the United States. It is a native of this country, and as it has not yet spread into the arid regions there is a possibility that these districts may never be burdened with it.

Importance:

Its damage, though not so great as that caused by some other pests, is a considerable tax on the fruit industry. The National Conservation Commission estimates the loss chargeable to it as follows: (10).

Apples,	$3,257,806.
Peach,	3,788,814.
Plum, Prune, etc.,	994,149.
Total,	$8,040,769.

This statement shows the magnitude of its injury, and indicates why it may be appropriately treated under apple pests.

Food Plants:

The plum curculio feeds upon, and oviposits in practically all pome and stone fruits, and there are records of oviposition in huckleberry, grape, strawberry, gooseberry, currant and wild persimmon, and even in the bark of trees and the black

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knot on the plum and cherry. Fortunately, however, it doubtless never matures on the grape, huckleberry, persimmon and similar fruits, and rarely on the pear. They seem to prefer the earlier and more tender-skinned varieties, both for egg-laying and feeding purposes.

Life History:

At about the time when the buds begin to show green in the spring, the beetles which have hibernated under rubbish on the ground, under rough bark, in the neighboring woods, or in other protected resorts, emerge and as soon as the young fruit enlarges, oviposition begins. The deposition of eggs goes on most rapidly during June, but continues through July, after which the majority of the beetles of this generation die, but a few may survive until September, or in rare instances until late fall.(3).

In feeding, the beetles gnaws out a small, round hole. When egg-laying, it makes a cresent-shaped cut around the point at which it has inserted the egg. These injuries are especially serious on young fruit, causing them to grow gnarly and misshapen. (8).

Riley estimates the number of eggs laid by each female at from fifty to one hundred. (1). Later, careful experiments by Quaintance and Smith, (4), and Jenne, (7), place the average at about one hundred and forty-five, ranging from 1 to 557, and the length of the period of incubation at 2.5 to 13.5, the average varying from 3.77 to 9.23 days. The young larva start tortuous burrows through the fruit, usually causing it to fall within a few days.

Crandall records the following average length of

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the period from the laying of the egg until the emerging from the apple:

In June,	18.07
In July,	19.15
In August,	21.55
In September,	26.00.

In less than an hour, after leaving the fruit, the larva is hidden a couple of inches beneath the ground. Under the direction of Quaintance, studies on the length of time spent in the ground have been made. (7).

Place.	Time spent in the soil before pupation.	Length of pupal instar.	Days in soil as beetle.	Total.
Washington, D. C.,	13.18	8.36	7.75	29.35
Douglas, Michigan,	12.18	14.12	7.10	33.28
Barnesville, Ga.,	16.08	9.18	5.62	30.89

We see that in about thirty days the perfect beetles emerge. There are an equal number of males and females. (7). They remain quiet for a day or two, allowing the body wall, beak and jaws to harden, then fly into the trees and begin feeding upon the fruit. Beetles of the new generation do not (except possibly in rare cases) pair, and no eggs are laid by them until the following spring. They cause the greatest loss to the orchardist, however, for the fruit is freely punctured for feeding, and the amount of this work increases as the season advances, ceasing only when no more fruit remains. (5). Late in the fall, the beetles hide in secure places for the winter. Quaintance estimates, on the basis of data by workers for the Bureau of Entomology, that there is a mortality of 70% among the hibernating beetles.

Thus, we see the entire period, from oviposition to appearance of the adult, amounts to about fifty days, and

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there is but one generation.

Natural Enemies:

There are many factors which hold the number of curculios in check. The mortality of the hibernating larva has already been mentioned. Drought during the pupal period and time of emergence of the beetles from the soil, scarcity of fruit for oviposition, due to frost, etc., are all important. It has also made parasitic and predacious enemies. Of the former class, Anaphoidea contracheli, Girault, is the only important parasitic on the egg. Of those feeding in the larva, Triaspis curculionis, Fitch, is the most important, causing, according to Quaintance, a mortality of from six per cent. to twelve per cent. (4). A variety of this species, Triaspis curculionis var. rufus, Riley, also feeds on the larva, and while developing to the adult form in the fall, remains in the cocoon until the following spring. Others are Microbracon mellitor Say. and other Hymenoptera. Also a Tachinid fly, Myiophasia aenea, Wiedemann, and Cholomyia inaequipes, Bigot. (7).

Among the parasitic enemies the ant is the most alert.

Riley also reports a species of thrips as very effective. There are many other insects which are generally predacious which include the curculio in their diet.

Within the limited confines of their hunting ground, poultry are valuable in checking the curculio, and the United States Bureau of Biological Survey found beetles in the stomachs of seven species of wild birds.

Control:

The depradations of the curculio led the pioneer

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settlers to seek some means of control, and many methods were suggested, most of which, however, were worthless. Jarring is the only one which has survived. This is based on the peculiar habit of the beetle of playing possum when disturbed. If a tree is sharply jarred, the insect will curl up its legs and fall to the ground, where its little, round, earth-colored body is very difficult to distinguish. Many contrivances have been invented for catching the falling curculios, the best of which consists of a white sheet supported by a frame work. This is sometimes shaped like an inverted umbrella, with a slit through which the trunk of the tree may pass, and placed on a wheelbarrow. Or, in the south, where labor is cheap, it is carried by four persons while a fifth strikes the tree with a heavy padded pole. No experiments have proven its economic value, but the large number of curculios captured has lead to its use in some large orchards of drupaceous fruits. It will probably never be depended upon in older apple orchards.

The value of cultivation in the campaign should be kept in mind by every enemy of the"Little Turk". As has been shown, the insect pupates only one to three inches beneath the surface of the ground. As these pupae are extremely tender and readily killed by the disturbing soil, the gain from frequent cultivation is evident. (7). Quaintance reports a percentage of benefit of 76.75% after comparing the results of a series of experiments. This adds one more reason to the many good ones advanced in favor of clean cultivation. (7).

The nature of the curculio's work makes spraying less effective in its control than it is in that of the codling moth. The egg is laid beneath the fruit, and the larva does all

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its feeding in the interior. The only vulnerable point in its history is, then, the beetle stage, and even here the possibilities are limited by the fact that the beetle punctures the skin and does most of its feeding under the pulp within. Since 1870, the question of the value of arsenicals for this pest has been argued, and evidence has beem presented in favor of both theories. It would be unprofitable in a limited discussion to follow this development. The summary would be that the spray has gradually grown in favor, and is now generally advised. This conclusion has been more easily reached because in most orchards several sprays must be applied anyway for other purposes, and even if they did not include a poison, there is little extra expense involved in the addition of a few pounds of arsenic. Thus, it is a question, not of whether the benefit derived in checking the curculio will pay for the spraying, but whether it is of any effect at all, and even the most skeptical of the careful workers have conceded it a slight value.

Quaintance and Jones, in 1912, recommended four applications: first, when the cluster buds are out, but before the blossoms fall; second, as soon as the petals fall; third, three or four weeks after the petals fall; and fourth, nine or ten weeks after the petals fall; and where the curculio is excessively troublesome, a treatment about mid-way between the third and fourth. (7). Experiments by Quaintance and Scott, reported in 1913, seem to show that where the codling moth and plum curculio are alone to be considered, one thorough spraying just after the petals fall is about as efficient as a schedule requiring three or more applications. In six orchards, where data was obtained, an average of 82.82% of fruit free from injury was obtained from

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the one-spray plats as compared with 82.40% of sound fruit on plats receiving the demonstration treatment. The percentage of sound fruit on the unsprayed trees was 55.50.

To sum up the evidence then, we may say that in an apple orchard troubled only with codling moth and curculio, one thorough intelligent application of an arsenical, just after the petals fall, will suffice. If other summer sprays are necessary for other pests, the arsenic should certainly be added, and that no amount of spraying will hold the curculio in check in an orchard which is uncultivated, unpruned or otherwise neglected.

Apple Curculio, Anthonomus quadrigibbus, Say.

History:

The apple curculio has occupied the attention of horticulturists for a much shorter period than has the plum curculio. It was not described until 1831 when Say named it Anthonomus quadrigibbus. It is a native of the United States where it has feed on the hawthorne and wild crab.

Superficial Appearance Compared to Plum Curculio:

The larva is a wrinkled, footless, dingy-white grub, which, when full-grown, is nearly half an inch in length. Some of the body segments in front of the middle are greatly enlarged on the back which gives the larva a humped-backed appearance and prevents it from straightening out. (5).

Riley has noted the chief differences in the appearance of the adults of the two curculios. He writes: "The snout of the plum curculio hangs down like the trunk of an elephant, it is so short, stout, and does not admit of being stretched out horizontally forwards - is scarcely as long as the head and thorax together, and can be folded back between the legs,

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where there is a groove to receive it. The plum curculio is broadest across the shoulders and narrows behind, and, moreover, the black sealing-wax-like knife-edged elevations on the back, with the pale band behind them, characterize it at once from all our other fruit boring snout beetles." (5).

"The apple, or four-humped curculio, is a smaller insect with a snout which sticks out more or less horizontally, and can be folded under, and which, in the male, is fully as long as the whole body. This insect has narrow shoulders and broadens behind, where it is furnished with four very conspicuous humps, from which it takes its name. It has neither the polished, black elevation nor the pale band of the plum curculio."

Life History:

The beetles emerge in the spring about the same time as the plum curculio, and soon after the blossoms disappear from the trees, begin laying eggs in the young fruit. Oviposition goes on as continuously as it does in the previously described insect, but as the period is shorter and its work slower, somwhat fewer eggs are deposited. The eggs hatch in about five days, and the larvae therefrom feed on the flesh of the apple for about twenty days, (6), where, according to Riley,(3), and Crandall, (5), they transform to pupae within the fruit. According to O'Kane, they pupate under the ground.(8). After remaining in the pupal form for about a week they change to beetles, and soon after appear as adults.

The young beetles do not injure fruit by feeding on it during the late summer and fall. According to Cramdall, by the first of August most of the beetles have disappeared from the trees and are found the ground in grass beds and under fallen

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leaves.

Their damage is not so great as that done by the plum curculio, not only because they are fewer in number and because their period of work is shorter, but also because their punctures are less destructive.

Control:

The control of this insect, though similar to that of the plum curculio, presents some additional difficulties. It is not so easily jarred, because it is less prone toplay possum, and it is more difficult to poison for the reason that in feeding they consume little of the exposed surface to which poison is applied. Instead of eliminating neighboring wild plum groves, as we should when fighting the plum curculio, we should avoid thickets of haw and wild crab.

Apple Weevil, Pseudanthonomus crataegi, Walsh.

History:

This insect was bred from Ceridomyid galls on crataegus by Walsh, in Illinois, and was described and named by him in 1866, but since then has received little attention.

Superficial Appearance:

The beetle may be distinguished from the other curculios mentioned by its much smaller size, lighter and browner color and absence of humps on the back.

Life History:

Its life history, as far as it is known, is not materially different from that of the apple curculio. The larva seems unable to subsist on apples that are growing vigorously on the tree, fruit which is soft with decay or shrivelled and dried being most acceptable.

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Control:

As the weevils usually remain in fallen apples for a week or more after they drop, destroying the fallen fruit will dispose of many of them. They are more susceptible to spraying than the other curculios, because they feed to some extent on the foliage. (6).

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HEMIPTERA.

Homoptera, Suborder.

Coccidae. (Scale Insects).

The suborder homoptera contains more than its share of troublesome species. The Coccidae, which is one of the most objectionable families of insects we have to combat, is only one of several very destructive groups. This family is characterized by having one pair of wings, the other being replaced by balancers on which there are one or more hooked spines which catch into the forewings.

The family is divided into four subfamilies:

1. Diaspinae. All scale insects in which the waxy covering is separable from the insect underneath. Absolutely fixed after once inserting beak.

2. Coccinae. More or less fixed after having once attached themselves. Variable. Includes Lecanimus, mealy-bugs and other soft scales.

3. Brachyscelinae. Gall makers. Movable until in galls. Occur in Australia and East India, but no forms in America.

4. Monophlebinae. Most primitive type. Movable throughout entire life. Occur in Asia and Africa, but no forms in America.

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Of these groups the Diaspinae are by far the most important, although the Coccinae produce some serious pests.

The Diaspinae are highly specialized, and sometimes limited to but one host plant. The family includes four important genera. These may be classified roughly as follows:

1. Aspidiotus. Scale of female nearly circular, with central or subcentral exuviae. Scale of male resembling that of female in color and texture, but slightly elongated, and exuviae eccentric.

2. Mytilaspis. Scale of female oyster shaped. Male practically same shape and color, but smaller.

3. Diaspis. Scale of female circular; exuviae eccentric; color white. Male parallel sided; elongated; white; carinated longitudinally.

4. Chionaspis. Female scale somewhat oyster-shaped; white or buff in color, but male like male of Diaspis.

The main points in the above description were taken from notes on a lecture delivered by Professor J. G. Sanders.

San Jose Scale, Aspidiotus perniciosus Comst.

Importance:

The important member of the genus Aspidiotus is the San Jose Scale. Though rare in Wisconsin it is of importance here, as in any district, because its capacity for harm probably exceeds that of any other scale insect known, because it attacks practically all decidious plants, and because it is almost impossible to exterminate when once introduced. (5).

History:

It was first described by Comstock in 1880, having been imported from China via Japan to California in the early

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seventies. Since then it has spread over practically the whole of the United States and Canada. (5).

Superficial Appearance:

The scale occurs on all sides of the plant, except the root. When numerous they lie close together, and frequently overlap, with several young ones clustering over the surface of a mature scale. The general appearance is a grayish, very slightly roughened, scurfy deposit which when thick resembles a coating of ashes. When crushed a yellowish, oily liquid will appear, resulting from the mashing of the soft insects beneath the scale. During the summer the hand lens will reveal numbers of orange colored larvae running about, and the snowy-white young scales will be interspersed with darker mature scales. Its detection is facilitated by the reddening which it produces on the skin of fruit and on tender twigs. (5).

Life History:

The winter is passed by this insect in a partly grown dormant condition under the protecting scale. When warm weather comes, the males are at this time in excess, transform to pupae and emerge. The females at this period have arrived at the stage of impregnation, and the delicate two-winged males disappear after a few days. About a month later the overwintered females begin to give birth to living young, and continue to produce for about six weeks, when they perish. The almost microscopic larva wanders to the nearest available point, contracts to a nearly circular form, and slowly works its long bristle-like sucking beak through the bark. The development of the scale begins even before the young larva has selected its feeding place, as very minute, white, waxy filaments, which spring from all parts of the

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body, rapidly become thicker, and slowly mat down to form the circular, white scale with a depressed ring and central elevation. The skin is cast off for the first time twelve days after the young appear, and consists of a splitting of the old skin around the outer edge of the flattened insect, the upper part being attached to the scale and the lower portion forming a ventral scale next to bark. Both sexes lose their legs and antennae at this time, and the males, which heretofore were indistinguishable from the females may now be recognized by the large purple eyes and elongate body from the eyeless females, which are practically flattened sacs with only the slender sucking bristle. Six days later, or when eighteen days old, the male molts to the propupa, and the male scale becomes an elongated oval in form. The antennae, legs and wings, now appear and are fairly well shaped when two days later the change to the true pupa takes place. After another four to six days, or from twenty-four to twenty-six days from birth, the mature winged males back out from under the scale. The female undergoes a second molt about eight days after the first, and thirteen to twenty days later, or when she is thirty-three to forty days old, gives birth to young. In one season there may be from three generations in the north to as many as five in the south. (5).

Natural Enemies:

The San Jose scale has a number of natural enemies. Among the more important are Apelinus fuscipennis, How, several species of lady bugs, among them a small black variety, Pentilia misella Lec, and a fungus disease, Sphaerostilbe cocophila, Tul, which, however, like other fungi, is very dependent on favorable climatic conditions. (5).

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Control:

The best method of preventing injury by this scale lies in excluding it from a district. This demands an understanding of its means of dispersal. By far the most important means of distribution is nursery stock. It is, of course, transported long distances in other ways, as on infested fruit, but danger from this source seems inconsiderable. (4). It may be spread locally by insects, birds, by winds, or human agencies, but owing to the inactivity of the females, it usually spreads slowly from tree to tree. The conclusion is, that the most efficient method of excluding this pest is by insisting upon some reliable certificate of inspection of nursery stock, preferably backed by a fumigation with HCN gas. (2). When San Jose Scale has gained a foothold, the control consists in the application of a contact insecticide, and indeed the same remedies which are applied against it will keep all the scale insects in check. (2). The following sprays are effective:

(a) Kerosene emulsion 10% to 20% kerosene. (6).

(b) Pure kerosene, but this has resulted in such serious injury that it has been almost entirely abolished. (11).

(c) Crude petroleum (43 to 45 degrees Baume) applied in a fine spray on a bright summy day seems less injurious to the trees than the pure kerosene. It contains more heavy oils, and consequently does not penetrate the bark so readily, and the light oils evaporating leave the heavy oils on the bark for some months, which aids in preventing young scales from getting a

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foothold. (11).

(d) Miscible oils diluted ten to twelve times are effective as winter washes. (11).

(e) Whale oil soap, or fish oil soap (two lbs. per gal. water) is fairly good for a winter wash if applied while hot, the soap being dissolved in hot water.

(f) The standard spray is the lime-sulphur wash. Its efficiency as a fungicide adds to its popularity. The stock solutions which are sold are usually of excellent quality. For the home manufacture of the solution, we can use two pounds of sulphur to every pound of pure calcium oxide. Thus the amount of lime used will vary in proportion to the amount of calcium in it. To this mixture add water at the rate of 25 gallons to every 40 lbs. of sulphur. Whether the commercial or the home-made solution be used, its strength should be tested with the Baume hydrometer, and then diluted in accordance with the tables published by the experiment stations.

European Fruit Scale, Aspidiotus ostraeformis, Curtis.

Relationship and Import:

This is a close relative of the San Jose Scale, and though it is improbable that in this country it will ever rank in importance with its pernicious cousin, it should be carefully watched. (7) (13).

Distribution:

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It is well known on various fruit trees in Europe. It has doubtless been in the United States much longer than the San Jose, and has become established in widely separated localities, both in this country and in Canada. (4).

Food Plants:

Its food plants are apple, cherry, maple, oak, peach and pear, as well as prune, currant, plum, ash, elm, Carolina poplar and willow. (13).

Superficial Appearance:

Its general appearance is similar to San Jose Scale. The sides of the scale are dark gray, while the center, which is nearly white, may be grayish or brown. The young appear to have a habit of arranging themselves at nearly equal distances from each other. The individual adult may attain a diameter of nearly one-eighth inch, and has a yellowish or orange nipple a little to one side of the center. The male is somewhat oval in outline. (13).

Life History:

The winter is passed by partly grown individuals, which become mature before the last of June. It has been reported as giving birth to living young, but the weight of authority seems to cast a doubt on this assertion. The young appear about the last of the month, and continue to emerge for several weeks. Two generations are produced in this latitude. (13).

Putnam Scale, Aspidictus ancylus, Putnam.

Description:

Putnam's scale is of importance because of the liability of its being mistaken for San Jose. It also resembles the European. The San Jose, however, usually has a much deeper

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concentric ring than the other two, in which it is either shallow or wanting. But even this is not an infallible test, because in the summer a San Jose which is growing rapidly often has a very shallow ring. When the scales are rubbed, the nipple of the European is red orange, that of the Putnam yellowish orange, and that of the San Jose still more yellow than the Putnam. As a rule, the Putnam is not massed as the European and San Jose, and the young are not so dark nor so flattened as those of the pernicious scale. (2) (13).

Life History:

The Putnam, like the two already described, passes the winter in a partly grown, though usually more mature, condition. There is but a single generation. The males appear the latter part of April, and the females deposit from thirty to forty eggs in the late spring or early summer. The crawling young may be seen during most of July, indicating that the hatching of the eggs extends over a considerable period. (13).

Food Plants and Injury:

It is found throughout most of the country on apple, cherry, currant, honey, locust, peach, pear, plum, walnut, etc., but rarely in sufficient quantity to cause serious injury. (4).

Cherry Scale, Aspidiotus forbesi, Johnson.

Distribution and Host Plants:

This scale is found on apple, cherry, currant, honey, locust, peach, pear, plum, walnut, etc., but is not very widely distributed. (11).

Superficial Appearance:

It can be distinguished from the San Jose by the

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much lighter color of the scale, and the orange-red exuviae, also the "dot" and "ring" is not so noticeable. (11).

Life History:

It winters partly grown, the males appearing in May, eggs and young being found as late as June 30th. In the north it produces two generations, the males of the second brood appearing from July 10th to August 1st, and the young of this generation from the first week in August until late in September. (11).

Scurfy Scale, Chionaspis furfura, Fitch.

Distribution:

The most important member of the genus Chionaspis, the scurfy dark louse, is found throughout most of the United States on apple, cherry, currant, elm, pear, etc. (4).

Superficial Appearance:

The insect often occurs in thick, dirty masses, and the form of the individual is much obscured. The individual female consists of a small yellowish pellicle (usually two are present), a large dark scale and a very much larger, irregularly shaped, whitish scale. The male scales are elongated, with a small yellowish pellicle and a very much larger, tricarinate, white scale. A rupture of a female scale in the winter reveals the purplish eggs beneath, and, when turned over, the shrunken body of the parent and the mass of eggs are exposed.

Life History:

The winter is passed in the egg beneath the protecting scale of the female. The reddish young appear about the middle to the last of May, and in about six weeks appear as a yellowish exuviae and a dark grayish scale 1 mm. long.

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The Rose Scale, Diaspis Rosae, Bouche.

This is a round or circular, pure white or very yellowish-white scale. It is not found on the apple, but may cause the careful orchardist concern for it is sometimes very common on neglected rose, raspberry, and blackberry bushes (especially near a wall or other shelter), where it attracts the attention by forming such striking contrast to the greenish or reddish shoots. The male insect is very small and narrow. The life history is similar to that of the Scurfy Scale.

Oyster Shell Bark Louse, Lepidosaphes ulmi L.(Mytilaspis pomorum, Bouche.

This is probably the most abundant scale on apples in the northwest. It also occurs on currant, cottonwood, lilac, pear, etc. (6). It is now known to occur all over the world. (5).

The adult female scale is about 3 mm. long, of a dark brown color, sometimes almost blackish, and shaped somewhat like an oyster shell. The male scale is much smaller, and with but one cast skin at the anterior end. (8).

The winter is passed in the egg under the scale. This egg hatches a week or two after the apples blossom, producing yellowish insects from which, in a day or two, white waxy filiaments exude, which soon mat down to form the protecting scale, to which the cast skins are added when the insect molts. The female loses her legs, antennae and eyes after the first molt, and when full grown is an elongate, yellowish, jelly-like mass, being simply a "reproductive scale". They become full grown in about eight to ten weeks, when they lay from forty to one hundred eggs, and then die. In the north there is but one generation a

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year, but southward there is a partial or complete second generation. When the males are full-grown, they emerge from the scales (which are bent upward like a hinge for the purpose (8)), as two-winged flies, fertilize the females, and die at once. (11).

Aphididae. (Plant Lice).

The plant lice belong to the Aphididae, the most abundant and destructive family of the suborder Homoptera. There are seven hundred and fifty species attacking as many or more different kinds of plants. Of these, four species commonly infest the apple in the United States: the wooly apple aphis (Schizoneura Lanigera, Fab.), the apple aphis (Aphis mali, Fitch), the European grain aphis (Siphocoryne avenae, Fab.) and the rosy apple aphis (Aphis malifoliae, Fitch). (7).

Wooly Apple Aphis, Schizoneura lanigera, Hausm.

History and Distribution:

There is a difference of opinion as to whether this species originated in America or Europe, but the weight of evidence seems to indicate the former. It is now almost ubiquitous. It was first noticed in England in 1787 on stock imported from America, was described in Germany by Hausmann in 1801, but did not attract much attention in this country until 1850. It has been reported from all over the United States, from the northern tier of states to Louisiana and New Mexico, but seems most abundant in the latitude of the Ohio Valley. (1).

Superficial Appearance:

It appears on the trunk and limbs of apple trees in clusters of individuals which are conspicuous on account of the wooly excretion with which the bodies are covered. The bark

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apparently ceases to grow at the point of attack, but swells into a large ridge about the cluster of lice, leaving them in a sheltered pit. The lice also frequently congregate in the axils of the leaves, and the forks of the branches. This species resembles the Grape Phylloxera in having a root form which causes knotty swellings on the fibrous roots. (13).

Life History:

Throughout the year there may be found on the trees a somewhat oval-shaped aphid of a purplish, or redish-brown color. This is the "queen mother" which secretes the characteristic woolly material. She gives birth to living young (minute, louse-like forms of a grayish-yellow color) which at first live beneath the wooly secretion close to the parent, but later creep away and produce generations of young. In October or November, or earlier in the south, a resting stage is reached, and pupae, or nymphs appear, which give rise to winged forms, which are also females, and are the parents of a true sexed generation of minute, wingless lice, the females of which give birth to a single "winter egg" which is attached within a crevice of the bark, and hatches in the spring into a female aphid. (10). In most sections of the country this louse lives over winter regularly upon the trees and limbs, as well as on the roots of the trees. Upon the roots it lives in all stages of growth, but upon the top all the lice die, except the last brood born in the fall. These leave the place of their birth before molting, and apparently without feeding or growing, to hunt a hiding place that will give them protection for the winter. The hiding places are beneath the dead bodies of the partly or fully grown lice (which all die from cold), beneath scales of the bark, or upon the crown or beneath the bark

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and loose dirt. The overwinter lice do not secrete any cottony covering until they begin to feed and grow the following spring. Thus, there may be four means of starting the summer infestation:

First: By the individuals which have lived over winter on the parts above ground and hidden in old wounds or scars.

Second: By the early hatching of the stem mothers.

Third: By the numerous immature lice which may hibernate at the base of the tree and near the surface of the ground.

Fourth: By the half-grown individuals which spend the winter on the roots and migrate upward in the spring. (8).

Natural Enemies:

Unlike most of the aphids, S. lanigera is largely protected from attacks of insect enemies by the wooly excretions which surround it. Chief among its foes are several species of the Ladybird Beetles, and those of the Syrphidae, or hovering flies. (11).

Prevention:

The control should begin with a thorough inspection of the nursery stock, any clods of dirt hanging to the roots should be washed off, and if lice are found either on the roots or top, the stock should be thoroughly sprayed with it or dipped into Lime Sulphur (1-10), or Black Leaf (1-60).

Control:

On parts attacked above ground, any spray which will kill other lice will destroy this species also. The spray must be applied with force enough to penetrate or wash off the

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white waxy secretion.

On parts attacked below ground, the sprays as used above ground will be efficient, but before they can be applied the infested roots must be exposed so that they can be made to reach the lice. According to C. P. Gillette of Colorado, the roots are not ordinarily infested more than six inches below the ground, or about two feet from the trees. (12).

The Green Apple Aphis, Aphis mali, Fab. (Aphis pomi, De Geer).

Importance:

The green apple aphis is one of the best known of the Aphididae. Its injury is much underestimated, for while it does little apparent damage, it retards the growth, especially of young trees, very seriously.

Superficial Appearance:

The body is pear-shaped. The wingless females are light greenish, with black honey tubes and dusky antennae. The winged females, which are the migratory forms, are greenish in color, with the head and wing-bearing portions of the body black. (12).

Origin and Distribution:

Aphis mali is of European origin, and has only recently made its appearance in this country. Mr. Pergande having first seen specimens collected in the United States in 1897. However, it is now distributed throughout the apple growing sections. (1).

Life History:

This species lives entirely upon the apple, pear and related plants, and does not migrate to grasses, weeds or

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other vegetables as does the following species. The elongated eggs (at first green, but later shiny black) are deposited in the fall by the sexual females upon young shoots of the trees and the water sprouts, the latter being the favorites. (13) (14). The eggs hatch the following spring into very small green lice which soon commence the attack on the newly opened leaves. After casting their skin three times, they develope into stem mothers, and these, as well as all the following generations of the summer months, are females which give birth to young. The leaves, owing to the punctures made by the insect, now curl up. The first generation are all wingless, but later in the spring many winged lice appear, and these migrate to other trees where they start new colonies, mostly wingless. (13). During October and November, the males and egg-laying females are produced, and the females lay the eggs which are to carry the insects through the winter. In New Jersey, Dr. Smith found seven of the agamic generations, followed by the development of the sexual generation in the fall.

Natural Enemies:

The aphids have an unusual number of parasites. Species of ladybirds (Coccinellidae), a yellow banded species of the genus Syrphus of the Syrphidae, several Hymenoptera, aphis lions and other neuroptera much like the aphis lions, but belonging to the family Hemerobiidae, are among its insect enemies. In addition entire colonies may be destroyed by fungus diseases when weather conditions are favorable.

Control:

The best control is a lime sulphur spray used winter strength (1-10 or 1-13) just before the buds open in the spring. H. F. Wilson (Oregon, Cir. 13) recommends spraying just as the

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buds are turning green, in order to catch many of the newly hatched young. Personal observation leads me to believe that many of the aphids will escape under this treatment, for a very short time after hatching, the youngsters are safely hidden in the buds which are just growing green. It is wise to plan the time and strength of the application so that all the aphids, scale insects and many of the fungus diseases may be combated by the same spray.

Summer Treatment:

No definite time can be given for summer treatment. It is simply a matter of spraying whenever and wherever the aphids are causing damage. A summer dose must be applied with sufficient pressure to force the spray under the curled leaves. Owing to the difficulty of accomplishing this, the summer treatment is less satisfactory than the winter method. Lime sulphur (1-5), black leaf (1-60), or kerosene emulsion containing six to seven per cent. oil is efficient.

European Grain Aphis, Siphocoryne avenae, Fab.

History:

Owing to the unusual life history of this insect there has long been much confusion concerning its name. Fitch considers it identical with Aphis mali. Two species, however, have been confused under this name, the present and the one just described, which fact was recognized by Mr. Pergande and also by Dr. J. B. Smith. Professor E. D. Sanderson, in 1903, described this insect as new, under the name of Aphis fitchi, but Pergande has subsequently shown that the insect is identical with the European grain aphis (Aphis avena, Fab.), and considers that the species really belongs to the genus Siphocoryne of Passerini. (7).

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Distribution:

This species is very generally distributed throughout the United States, and twenty-two plants upon which it has been observed are recorded, comprising apple, pear, quince, plum, rye, oats, wheat and some grasses.

Life History:

The shiny, jet-black, winter eggs are deposited in the fall around the buds of the more terminal shoots, at crotches of limbs, and in cracks and under scales of the bark. The eggs are quite small, but may be readily detected with the unaided eye. These hatch in the spring, about the time the young leaves of the apple are pushing out, and the small greenish lice when full-grown soon begin the production of living young, most of which develop into the winged agamic form which migrates to other trees and localities where new colonies are started, the progeny of the third generation also being wingless. In all, some five generations develop on the apple, but by early June, in the latitude of Washington, the trees are free from them, and the aphids have become established on the other host plants. Upon the approach of fall, apple trees are again infested, the true females are soon produced, and the winged males come from the grasses upon which they have developed. Winter eggs are deposited during September, October and early November. (7).

Rosy Apple Aphis, Aphis malifoliae, Fitch.

The rosy apple aphis, regarded by Pergande as Aphis malifoliae, Fitch, and determined by Sanderson as Aphis sorbi, Kaltenbach, is readily distinguished from the preceding by its larger size, rounder body, and unusually rosy color, which, however, may vary from salmon to tan or even slaty gray or black,

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the body being covered with a whitish pulverulence. This species is generally distributed in the United States, and is common on the apple, but has been taken on pear.

Life History:

The life history is imperfectly known. Winter eggs are deposited in the autumn by sexual females, and more often on the trunks and larger limbs than with the other species mentioned. They hatch in the spring as the apple leaves are pushing out. Three generations from the egg are said to occur on the apple in the spring, many individuals of the second and third developing wings and migrating to other host plants. After the third generation the apple is deserted by the insects until fall, when the return migrants appear to give rise to true sexual forms, the females depositing eggs as described. (7).

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Approved this 13th day of March, 1914.

J. L. Sanders

L. R. Jones

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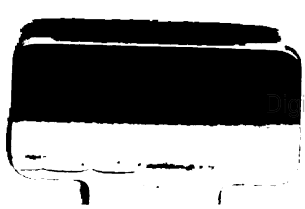

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